

Transfer of Heat

In the previous chapter you have learnt that heat flows from a body at a higher temperature to a body at a lower temperature, but how does this transfer take place? You will find the answer to this question in the chapter transfer of heat.

There are three ways in which heat is transferred from one body to another. These are

- Conduction
- Convection
- Radiation

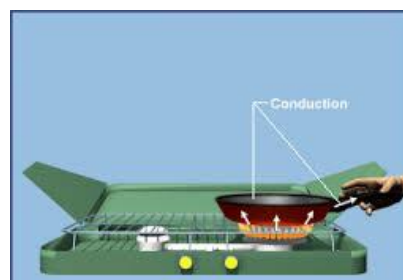
Conduction of heat

Conduction is a process of heat transfer that happens when two bodies are in direct contact with each other. For example, you pour hot water in a metal tumbler, the tumbler also becomes hot. Here, heat is transferred from the hot water to the metal tumbler.

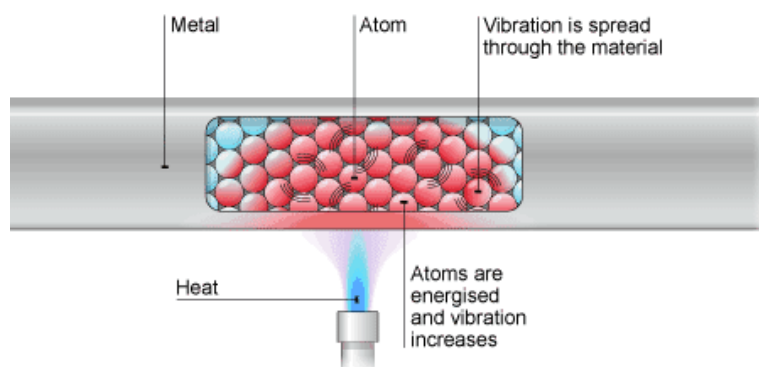
Thus we can define conduction as the process of heat transfer from a body at a higher temperature to a body at a lower temperature without actual movement of the particles.

When you heat food on a gas stove, heat is transferred from the gas stove to the vessel and from the vessel to the food inside it.

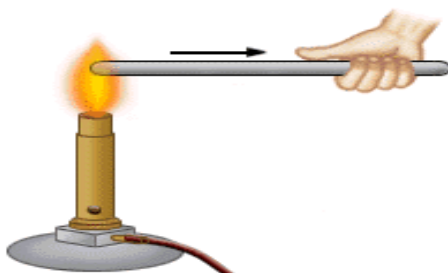
Conduction takes place only in solids. This is because in solids the molecules are tightly packed and are not able to move from one place to another.



When a solid is heated, the molecules start vibrating about their mean position. The vibrating molecules collide with the neighbouring molecules, as a result the vibration of the neighbouring molecules increases.



When we hold a metal rod near the candle flame as shown in the figure, the end of the rod closer to the flame becomes hot first and the heat is transferred to the cooler end of the rod. Thus heat is transferred from one end of the rod to the other end.



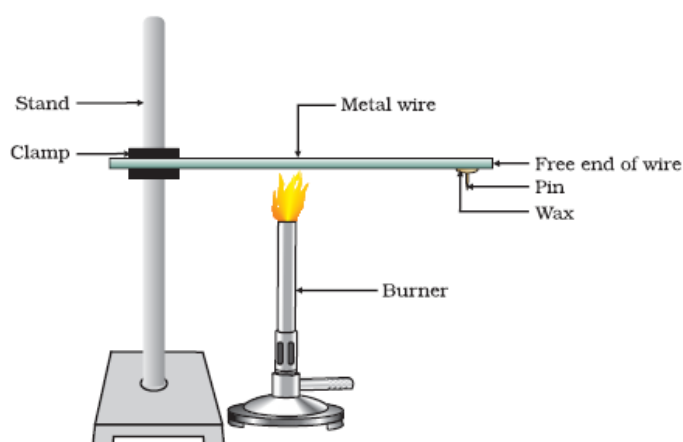
Good conductors and bad conductors of heat

Materials such as silver, copper, brass and aluminium that allow heat to pass through them easily are called good conductors of heat. However, the conductivity for different metals is different.

Materials which do not conduct heat easily are called bad conductors or insulators of heat. Liquids and gases are poor conductors of heat. Materials like glass, wood, cork are also examples for bad conductors.

Activity-1: To show that metals are good conductors of heat.

- Take an aluminium or copper wire. Clamp this wire on a stand, as shown in Fig. 3.1.
- Fix a pin to the free end of the wire using wax.
- Heat the wire with a spirit lamp, candle or a burner near the place where it is clamped.
- What do you observe after some time?
- Note your observations. Does the metal wire melt?

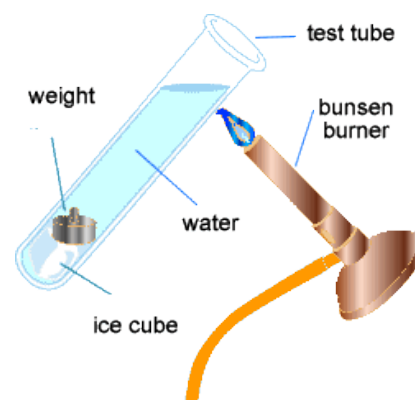


The above activity shows that metals are good conductors of heat. The best conductors of heat are silver and copper. Lead and mercury are comparatively poor conductors of heat.

Activity-2: To show that water is a poor conductor of heat.

If you fix an ice cube at the bottom of a test tube of water and then heat the water at the top of the tube, you will find that the water will boil at the top of the tube and yet the ice cube will remain frozen.

This is because water is a poor conductor of heat. Most of the heat will move in a convection current within the water at the top of the test tube, only a small fraction of it will conduct down to the ice cube.



Applications of good and bad conductors of heat

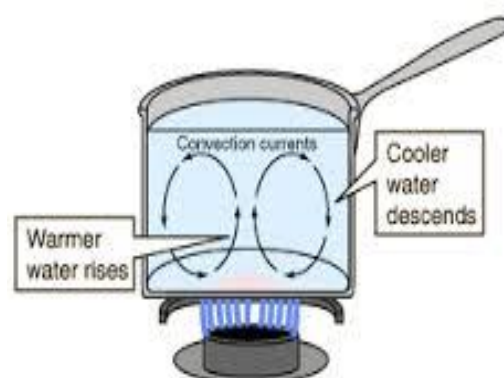
- Cooking utensils are made of metals to allow heat to flow quickly to the food that is cooked.
- Mercury is used as a thermometric liquid in a thermometer.
- The tip of a soldering gun is made of copper, as copper conducts heat easily.
- Plastic handles are bad conductors, so they are used for handles of cookware.
- Tablemats are made of cloth, plastic or wood as they do not damage the table.
- Mud houses remain cool in summer, as mud is a poor conductor of heat.
- Woollen clothes, quilts and blankets are used to keep our body warm in winter. This is because of the air spaces present in the blankets that trap air between them and our body and prevent the heat from our body to escape out.



4.2 Convection of heat

When liquids and gases are heated, the molecules close to the source of heat get heated first and thus expand. Due to expansion the volume increases and density decreases. The lighter molecules rise up and the cooler molecules take their place. This process continues, setting up convection current.

Thus, convection is a process of heat transfer in fluids due to the actual movement of molecules.

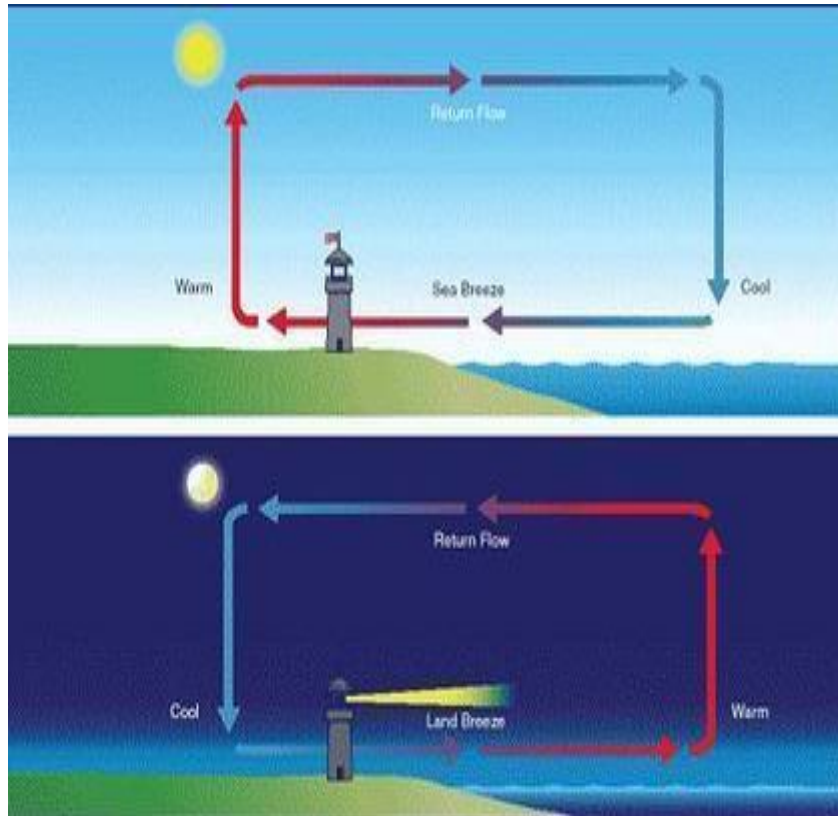


Convection cannot occur in solids as the molecules in a solid are tightly packed.

Convection currents in nature

The sun can heat the air making it rise while cooler air sinks. This causes a large current in the earth's atmosphere. These currents are the cause of winds

Sea breeze and land breeze

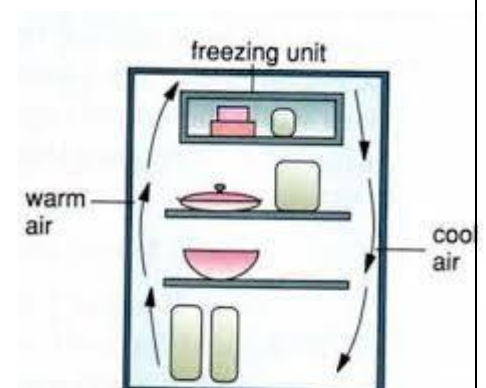


Convection currents are caused due to the unequal heating up of the earth's surface. During the day, the land gets heated up faster than the sea. The warm air over the land rises up and the cool air from the sea takes its place. So during the day, breeze tends to blow from the sea to the land. This is called sea breeze.

At night, the land cools down faster than the sea. The warm air over the sea rises up and the cool air from the land takes its place. So at night breeze tends to blow from the land to the sea. This is called land breeze.

Applications of convection currents

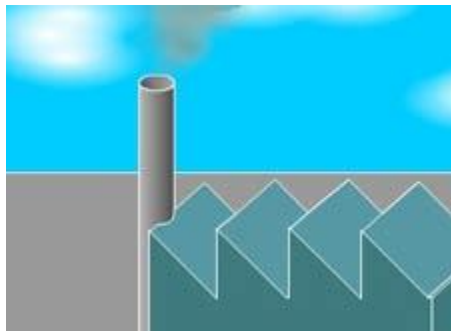
- Freezing chest in a refrigerator is placed on the top. So that the warm air rises up and the cool air from the freezing chest moves down and takes its place.
- Air-conditioners are always installed high so that the cool air moves down and cools the entire room.



- Ventilators at the top of the room lets hot air out

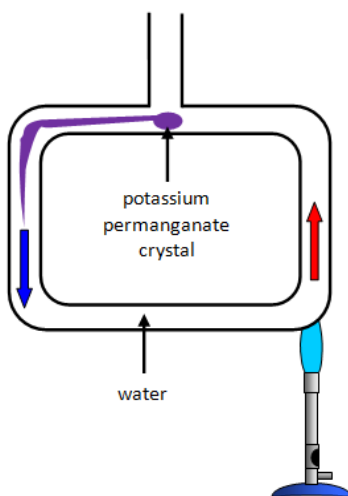
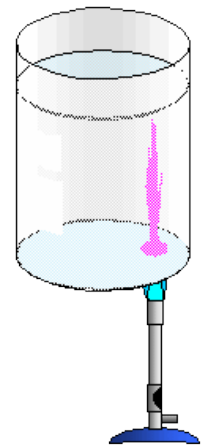


- Chimneys are provided in factories for letting out gases or smoke.



Activity-3: Convection in water

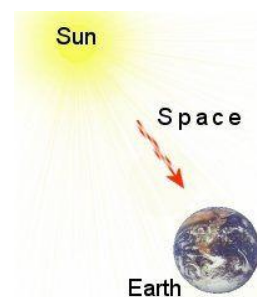
Fill a beaker with cold water and then carefully drop a few crystals of potassium permanganate into it so that they fall close to one side of the beaker. Now heat the base of the beaker just under where the crystals have fallen. You should see the colour rise up this side, go across the top and then fall down the other side of the beaker — this is convection current.



You can also use the special piece of apparatus shown in the diagram. It is a "square" glass tube filled with water. Drop a crystal of potassium permanganate into the top and then heat one of the bottom corners gently. You will see the colour begin to move round the tube going down the limb opposite the heating and then rising up the other side above the Bunsen due to convection currents in the water.

4.3 Radiation of heat

The sun is far away from the earth. The space between the sun and the earth is empty. There are no molecules in this space. So heat from the sun cannot reach us through conduction or convection. We receive heat from the sun by the process of radiation.



Thus, radiation is a process by which heat is transferred from a hot body to a cold body directly without heating the medium in between.

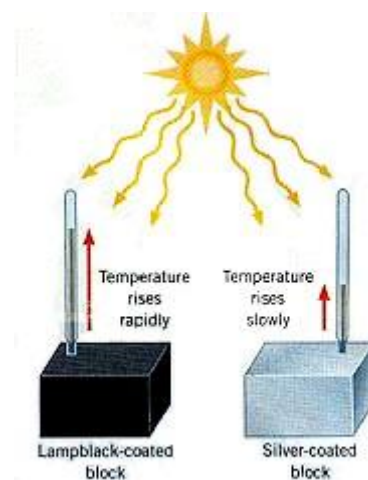
An electric bulb, hot iron, fire etc are other examples for radiation.

Absorption and emission of radiant energy

All objects above 0 K (absolute zero) emit electromagnetic radiation because of the thermal motion of their atoms. Thus they are emitting energy in the form of electromagnetic radiation. The higher the temperature, the more energy they emit per second. We also adsorb radiation emitted by other objects near us. If we are warmer than the walls of the room around us, we transfer more heat to the walls by the radiation than we receive from the walls, providing a net transfer of heat to the walls. If we are cooler than the walls we will receive more than we emit, thus gaining energy.

Some objects are good at absorbing radiation while others are not. Good absorbers are also good emitters of radiation and poor absorbers are poor emitters. A perfect absorber is called a blackbody and absorbs all the radiation striking it. White objects tend to reflect radiation rather than absorbing it, that is they are poor absorbers. However poor absorbers are also poor emitters and white objects are poor emitters of radiation.

If you are in the sun and wear black clothing, your clothing will absorb the light and warm up. If you wear white clothing, it will reflect the light rather than absorb it. It will not warm up as fast. White snow reflects most of the light and as a result it warms up more slowly on a sunny day than snow that has dirt or other debris on it that makes its surface darker.



Reflection of radiant energy

When radiant energy falls on matter, part of it is reflected back. A good reflector absorbs very little heat energy. Shining and white bodies are good reflectors. Black bodies are poor reflectors of heat.

Petrol storage tanks are made of aluminium to prevent them from absorbing heat falling on them.

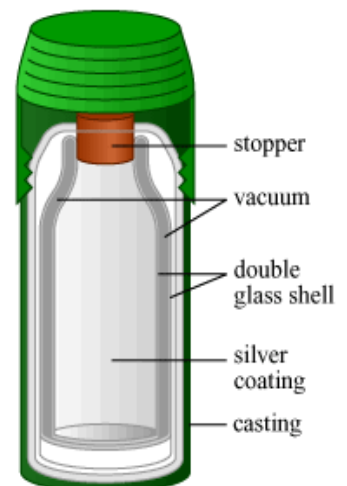
Application of absorption and reflection of heat

1. Car radiators usually are a dark colour so that they can get rid of the heat efficiently.
2. Aluminium foil is sometimes put behind radiators to reflect the heat out into the room.
3. A vacuum flask has shiny surfaces on the vacuum side to prevent heat loss
4. White clothes are worn in summer as they reflect the heat better than dark ones.
5. Spacecraft have shiny surfaces to reflect the radiation from the Sun.
6. Highly polished teapots will keep hot longer as their surfaces do not give out heat so well.
7. White washed buildings will keep cooler in hot weather than darker ones.

4.4 Thermos flask

The thermos flask was invented by James Dewar in 1820. It is used to keep hot things hot and cold things cold. It prevents heat loss by conduction, convection and radiation.

A thermos flask consists of a glass bottle with double walls. Glass being an insulator prevents heat loss by conduction. The vacuum present between the double walls prevents heat loss by conduction and convection. The outer surface of the inner wall and the inner surface of the outer walls are silvered to prevent heat loss by radiation. The cork at the mouth of the bottle prevents heat loss by convection. Thus, the thermos flask is designed to prevent heat loss due to any mode of heat transfer.



References: www.schoolphysics.co.uk

www.cyberphysics.co.uk

